ARSENIC

By William E. Brooks

Domestic tables were prepared by Elsie Isaac, statistical assistant, and the world production table was prepared by Regina R. Coleman, international data coordinator.

Domestic imports and use of arsenic trioxide (As_2O_3) declined dramatically in 2004 because of a voluntary phaseout of As_2O_3 as a component of wood preservatives at yearend 2003. Apparent consumption of arsenic metal and compounds in 2004 fell to 6,800 metric tons (t) from 21,600 metric tons (t) in 2003, a decline of approximately 70%. The United States produced no As_2O_3 or arsenic metal in 2004, and there has been no domestic production of As_2O_3 since 1985 when the copper smelter in Tacoma, WA, closed. The United States, however, remained the world's leading consumer of arsenic, as As_2O_3, primarily as a component of chromated copper arsenate (CCA), a widely used pesticide-preservative for pressure-treated wood products. Domestic demand was met entirely by imported As_2O_3 and arsenic metal, mainly from China, the leading global supplier of As_2O_3 and arsenic metal. Morocco and Mexico also supplied the United States with significant quantities of As_2O_3, and Japan was an important source of arsenic metal.

Legislation and Government Programs

In 2003, in response to consumer health concerns, U.S. manufacturers of arsenic-containing wood preservatives began a voluntary transition from CCA to alternative wood preservatives after consultations with the U.S. Environmental Protection Agency (EPA) (American Wood Preservers Institute, 2003§[1]; U.S. Environmental Protection Agency, 2003§). Wood treated with CCA prior to December 31, 2003, the voluntary phaseout date for CCA treatment of wood used for boardwalks, decks, fencing, gazebos, picnic tables, and play structures, could still be used. CCA-treated wood structures already in place would not be affected. Industrial-use wood products, such as marine timbers and pilings, utility poles, shakes and shingles, plywood roof decking, plywood flooring, and glue-laminated beams, however, may still be treated with CCA. The EPA indicated that there was no reason to remove CCA-treated structures or remove soils near these structures. In order to better inform buyers, however, the EPA required that CCA-treated lumber, which commonly has a pale greenish color, be labeled with a red and white tag indicating that the wood had been treated with CCA (U.S. Environmental Protection Agency, 2002). Safe handling information and site use precautions, as well as a toll free number and Web site, were also to be included on the label (Home Depot Inc., The, 2004). In 2004, the EPA conducted public technical briefings and made available documents that were developed as a part of its risk assessment of wood preservatives containing arsenic and other metals used as pesticides for wood preservation (U.S. Environmental Protection Agency, 2004).

The U.S. Food and Drug Administration proposed to amend its bottled water standards by revising the allowable level of arsenic in the water and requiring bottled water manufacturers to monitor their products at least once each year. This rule would insure that the amount of arsenic in bottled water would be comparable to the quality of public drinking water (U.S. Food and Drug Administration, 2004).

Environmental Issues

Arsenic and human health, as it related to groundwater and drinking water, continued to be of global concern. Natural arsenic in aquifers, geothermal systems, and the food chain was the subject of a workshop in Florence, Italy, sponsored by the International Geological Congress (2003§). As an example, groundwater in Bangladesh may contain 50 to 300 micrograms per liter (µg/l) of arsenic with 50 µg/l considered dangerous in drinking water by the Bangladesh government. The EPA considers 10 µg/l as an upper limit for drinking water. High levels of arsenic have been found in groundwater in parts of Argentina, Chile, China, India, Mexico, Nepal, Vietnam, and the United States (Pearce, 2003; Chowdhury, 2004). Arsenic leached from pesticides and mining waste has been blamed for contamination of water in rural and urban water supplies in parts of Peru (Luna, 2005).

Since 2000, U.S. Geological Survey (USGS) hydrologists have researched the use of deep aquifers in South Asia as a way of providing better water to local residents of the region (Dr. John Whitney, hydrologist, U.S. Geological Survey, oral commun., March 10, 2005). The U.S. Department of Energy's Arsenic Water Technology Partnership Program was seeking to commercialize bench-scale water treatment options to serve rural communities in the Western United States (Dr. Malcolm Siegel, hydrologist, Sandia National Laboratories, oral commun., March 3, 2005). The University of California-Berkeley coordinated an Arsenic Health Effects Research Program (Smith, 2003§). Arsenic is an element contained in many electronic products, and local government projects were aimed at public awareness and providing convenient dropoff locations for arsenic-containing, end-of-service electronic devices. On its Web site, the Agency for Toxic Substances and Disease Registry provided a toll-free telephone number as well as answers to a number of health-related questions, such as how arsenic affects children and how families could reduce their risk for exposure to arsenic (Agency for Toxic Substances and Disease Registry, 2005§).

With the banning of CCA in many nations, including Australia, Denmark, Germany, Indonesia, Japan, Sweden, Switzerland, Vietnam, and the United States, the market for arsenic has declined considerably (Clean Water Action, 2001§). This has affected arsenic production and has also raised environmental concern about safe disposal of byproduct arsenic that is produced during the

[1]References that include a section mark (§) are found in the Internet References Cited section.

processing of base and precious metals, the source of most arsenic. The metals industry, therefore, has promoted short courses that address the role of arsenic in metals-processing, the treatment of arsenic as a byproduct, and treatment of wastewater (Ramachandran and Demopoulos, 2004).

Arsenic, as As_2O_3, was also used in bait stations for the control of Argentine, big-headed, fire, ghost, harvester, and other ants (Drees and others, 2004§; Grant Laboratories, Inc., 2004§). All arsenical insecticides are stomach poisons to insects and leave water-insoluble residues on plant leaves and soil layers (Matsumura, 1976, p. 10). Tobacco farmers around the world use arsenical pesticides to kill ants and other insects, and the arsenic absorbed by the plant may find its way into cigarettes and smokers' lungs (Health Canada, 2004§).

Remediation of an area contaminated by leached arsenic from a World War I chemical weapons testing station in a Washington, DC, neighborhood continued. Levels of arsenic, above the risk benchmark set by the EPA were found, thus requiring removal and replacement of 2 feet of soil.

Consumption

In 2004, the United States remained the world's leading consumer of arsenic. In response to the voluntary ban on CCA at yearend 2003, the global arsenic market declined sharply. Apparent domestic demand dropped to 6,800 t in 2004 from 21,600 t of arsenic in 2003. The estimated value of arsenic compounds and metal consumed domestically dropped to approximately $4 million in 2004 from approximately $14 million in 2003.

In 2004, approximately 65% of the arsenic, as As_2O_3, was used in the wood preservative industry, down from about 90% in previous years; the remainder was used in agricultural chemicals, such as insecticides, herbicides, and fertilizers. The major U.S. producers of arsenical wood preservatives included Arch Wood Protection, Inc., Smyrna, GA; Chemical Specialties, Inc., Charlotte, NC; and Osmose Wood Preserving, Inc., Buffalo, NY. Other applications of arsenic included use as a bubble dispersant or decoloring agent in glassmaking or for arsenic trisulfide glass, a specialty optical material (Harrick Optical Materials, 2003§).

Reduction of As_2O_3 accounted for all world output of commercial-grade (99%-pure) arsenic metal. There are, however, three processes for the production of arsenic metal: 1) purification and reduction of As_2O_3 trioxide; 2) purification and reduction of arsenic trichloride; and 3) heat decomposition of arsine, a very toxic form of arsenic (Roskill Information Services Ltd., 1992, p. 2). China continued to be the leading world producer of commercial-grade arsenic metal, followed by Japan and Germany.

The demand for arsenic metal is limited; however, arsenic metal may be alloyed with lead and antimony for ammunition, solders, and other applications. Arsenic is one of several metals used as an antifriction additive to metals (babbitts) used for bearings. Grids and posts in lead-acid storage batteries are strengthened by the addition of arsenic metal. Gallium arsenide (GaAs) semiconductors are used in solar cells, light emitting diodes, and lasers. Gallium-arsenic and indium-arsenic semiconductors for use in computers and electronic devices require high-purity (99.9999%-pure) arsenic metal. Arsenic is an important component of GaAs wafers for electronics applications. In 2002, the domestic demand for gallium and arsenic in wafer production declined significantly owing to the buildup of the domestic GaAs inventory, closure of several domestic plants, and increased wafer manufacturing in China. Based on reported consumption of gallium, domestic consumption of arsenic metal in GaAs semiconductors fell from a peak of about 40 t in 2000, to 19 t in 2002 (Kramer, 2004). In 2004, consumption was estimated to have recovered slightly to about 20 t.

World Review

In 2004, As_2O_3 was obtained from the treatment of nonferrous ores or concentrates in 14 countries. Smelter dusts and residues were recovered from plants in several other countries; however, these were not processed to commercial-grade As_2O_3 and may have been stockpiled for future treatment. In 2004, China remained the world's leading producer of As_2O_3, followed by Chile and Peru. Country data are estimated and subject to revision because most countries do not report their As_2O_3 production.

Though production data were not available, trade data indicated a significant decline in China's As_2O_3 production in 2004. Imports into the United States from China fell to 3,000 t from 20,600 t in 2003. Trade news articles indicated that in response to the voluntary ban of CCA in the United States, production at some Chinese facilities was halted, stocks accumulated, and producers had difficulties finding markets (Metal-Pages, 2004a§-c§). Research of the arsenic market and trade data for China resulted in a major upward revision of USGS estimates of China's arsenic production in past years. These revised estimates show a dramatic decline in production to 30,000 t in 2004 from approximately 40,000 t during 2000-03.

Outlook

World resources of arsenic are adequate to meet projected needs given the availability of arsenic from nonferrous metal processing in 14 countries.

The decision by the wood preservative industry to voluntarily eliminate the use of CCA as a wood preservative for specified wood products by the end of 2003 has led to the decline in U.S. demand and has demonstrably affected As_2O_3 production in China. The domestic market for CCA-treated wood, for such industrial applications as marine timber, plywood roofing, and utility poles, is expected to continue. Environmental and human health concerns, however, will continue to encourage use of alternative wood preservatives, concrete, plastic, or wood lumber alternatives in place of CCA-treated wood.

The electronics industry is expected to continue to require high-purity arsenic for production of GaAs semiconductors for automotive uses, military and space applications, solar cells, and telecommunications. Arsenic metal is expected to continue to be used in the production of ammunition and other alloys.

References Cited

Chowdhury, A.M.R., 2004, Arsenic crisis in Bangladesh: Scientific American, v. 291, no. 2, August, p. 87-91.
Home Depot, Inc., The, 2004, Consumer safety information sheet, inorganic arsenical pressure-treated wood: The Home Depot, Inc., GEN-791, 1 p.
Kramer, D.K, 2004, Gallium, *in* Metals and minerals: U.S. Geological Survey Minerals Yearbook 2002, v. I, p. 29.1-29.10.
Luna, Nelly, 2005, Eliminación de arsenico en el agua requiere acción concertada [Elimination of arsenic in water requires concerted action]: El Comercio [Lima, Peru], May 22, p. A6.
Matsumura, F.F., 1976, Toxicology of insecticides: New York, NY, Plenum Press, 503 p.
Pearce, Fred, 2003, Arsenic's fatal legacy grows: New Scientist, v. 179, no. 2407, August 9, p. 4-5.
Ramachandran, V.R., and Demopoulous, G.P., 2004, Arsenic—Its processing, removal, and stabilization in non-ferrous metal industry: Journal of Metals, v. 56, no. 11, November, p. 7.
Roskill Information Services Ltd., 1992, The economics of arsenic (8th ed.): London, United Kingdom, Roskill Information Services Ltd., 149 p.
U.S. Environmental Protection Agency, 2002, Whitman announces transition from consumer use of treated wood containing arsenic: U.S. Environmental Protection Agency press release, February 12, 1 p.
U.S. Environmental Protection Agency, 2004, Notice of availability of the preliminary risk assessment for wood preservatives containing arsenic and/or chromium reregistration eligibility decision: Federal Register, v. 69, no. 52, March 17, p. 12653-12655.
U.S. Food and Drug Administration, 2004, Beverages, bottled water: Federal Register, v. 69, no. 231, December 2, p. 70082-70091.

Internet References Cited

Agency for Toxic Substances and Disease Registry, 2005, ToxFAQS for arsenic, accessed April 27, 2005, at URL http://www.atsdr.cdc.gov/tfacts2.html.
American Wood Preservers Institute, 2003, Manufacturers to transition to new generation of wood preservatives, accessed May 6, 2003, at URL http://www.preservewood.com/news/020212ccatrans.html.
Clean Water Action, 2001, Sealing arsenic-treated wood, accessed April 22, 2004, at URL http://www.preventingharm.org/pdf/cca_seal.pdf.
Drees, B.M., Barr, C.L., Cavazos, R.R., and Vinson, S.B., 2004, Laboratory and field evaluation of sodium arsenate bait stations for red imported fire ant control, accessed July 14, 2004, at URL http://fireant.tamu.edu/research/arr/Category/individual/89-91Pg48/89-91Pg48.htm.
Grant Laboratories, Inc., 2004, Material safety data sheet, accessed July 14, 2004, at URL http://www.laraison.com/CGP_Catalog/MSDS/grant_01.pdf.
Harrick Optical Materials, 2003, Arsenic trisulfide glass, accessed March 21, 2003, at URL http://www.harricksci.com/infoserver/Optical%20Materials/Arsenic%20Trisulfide.htm.
Health Canada, 2004, Cigarettes inside out, accessed April 2, 2004, at URL http://www.hc-sc.gc.ca/hecs-sesc/tobacco/youth/scoopinlist.html.
International Geological Congress, 2003, Natural arsenic in groundwater, Pre-Congress Workshop BWO 06, accessed November 13, 2003, at URL http://www.geos.iitb.ac.in/arsenicflorence.
Metal-Pages, 2004a, Arsenic dead, accessed November 15, 2004, via URL http://www.metal-pages.com.
Metal-Pages, 2004b, Arsenic producers hibernate, accessed November 23, 2004, via URL http://www.metal-pages.com.
Metal-Pages, 2004c, China arsenic halts production, accessed September 22, 2004, via URL http://www.metal-pages.com.
Smith, A.H., 2003, Arsenic Health Effects Research Program, accessed November 13, 2003, at URL http://ist-socrates.berkeley.edu/~asrg/pubab30.html.
U.S. Environmental Protection Agency, 2003, Chromated copper arsenate and its use as a wood preservative, accessed May 6, 2003, at URL http://www.epa.gov/pesticides/factsheets/chemicals/1file.htm.

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

Arsenic. Ch. in Mineral Commodity Summaries, annual.
Arsenic. Ch. in United States Mineral Resources, Professional Paper 820, 1973.
Gallium. Ch. in Minerals Yearbook, annual.

Other

1996 Wood Preserving Industry Production Statistical Report. American Wood Preserving Institute, 1998.
American Wood Preserving Institute.
Gallium and Gallium Arsenide—Supply, Technology, and Uses. U.S. Bureau of Mines Information Circular 9208, 1988.
Materials Flow of Arsenic in the United States. U.S. Bureau of Mines Information Circular 9382, 1994.
Materials, A Report of the U.S. Interagency Working Group on Industrial Ecology, Material and Energy Flows. U.S. Environmental Protection Agency, 1998.

TABLE 1
ARSENIC SUPPLY-DEMAND RELATIONS[1]

(Metric tons of arsenic content)

	2000	2001	2002	2003	2004
U.S. supply:					
Imports:					
Metal	830	1,030	879	990	872
Compounds	23,600	23,900	18,800	20,800	6,150
Total	24,500	25,000	19,700	21,700	7,020
Distribution of U.S. supply:					
Exports[2]	41	57	100	173	220
Apparent demand	24,400	24,900	19,600	21,600	6,800
Estimated U.S. use:					
Agricultural chemicals	950	1,000	750	860	850
Glass	700	750	700	660	650
Wood preservatives	21,800	21,900	17,300	19,200	4,450
Nonferrous alloys and electronics	700	1,000	650	660	650
Other	250	250	200	200	200
Total	24,400	24,900	19,600	21,600	6,800

[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Metal only.

TABLE 2

U.S. IMPORTS FOR CONSUMPTION OF ARSENIC PRODUCTS[1]

	2003		2004	
Class and country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Arsenic trioxide:				
Belgium	381	$244	292	$202
Bolivia	150	86	180	101
Chile	181	94	104	44
China	20,600	9,910	3,040	1,340
Germany	7	28	54	107
Hong Kong	191	114	464	230
Japan	94	62	--	--
Mexico	612	444	927	558
Morocco	5,130	2,790	2,950	1,450
Spain	--	--	91	43
Total	27,300	13,800	8,090	4,080
Arsenic acid:				
China	--	--	20	20
France	1 r	6 r	2	12
Total	1 r	6 r	22	32
Arsenic sulfide:				
Canada	(2)	(2)	(2)	(2)
Russia	(3)	5 r	(3)	2
Total	(2)	5 r	(2)	2
Arsenic metal:				
China	827	1,630	730	1,300
Germany	3	515	6	847
Hong Kong	--	--	20	20
Japan	160	896	116	862
United Kingdom	--	--	(2)	6
Total	990	3,040	872	3,030

[r]Revised. -- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Revised to zero.

[3]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 3
ARSENIC TRIOXIDE: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2, 3]

(Metric tons)

Country[4]	2000	2001	2002	2003	2004
Belgium	1,500	1,000	1,000	1,000	1,000
Bolivia	318 [5]	846 [5]	237 [5]	276 [r, 5]	300
Canada	250	250	250	250	250
Chile	8,000	8,000	8,000	8,000	8,000
China	40,000 [r]	39,500 [r]	40,000 [r]	40,000 [r]	30,000
France	1,000	1,000	1,000	1,000	1,000
Germany	200	200 [r]	200 [r]	200 [r]	200
Ghana[6]	3,000	--	--	--	--
Iran	400	400	400	400	400
Japan	40	40	40	40	40
Kazakhstan	1,500	1,500	1,500	1,500	1,500
Mexico	2,522 [5]	2,381 [5]	1,946 [5]	1,729 [r, 5]	1,800
Peru[7]	2,495 [5]	2,800 [5]	2,970 [5]	3,000	3,500
Portugal	50	50	50	50	50
Russia	1,500	1,500	1,500	1,500	1,500
Total	62,800 [r]	59,500 [r]	59,100 [r]	58,900 [r]	49,500

[r]Revised. -- Zero.

[1]Including calculated arsenic trioxide equivalent of output of elemental arsenic compounds other than arsenic trioxide where inclusion of such materials would not duplicate reported arsenic trioxide production.

[2]World totals and estimated data have been rounded to no more than three significant digits; may not add to totals shown.

[3]Table includes data available through April 1, 2005.

[4]Austria, Hungary, the Republic of Korea, Serbia and Montenegro, South Africa, Spain, Ukraine, the United Kingdom, and Zimbabwe have produced arsenic and/or arsenic compounds in previous years, but information is inadequate to make estimates of output levels, if any.

[5]Reported figure.

[6]Production ceased in mid-2000. Ashanti Goldfields Ltd. Obuasi roaster closed.

[7]Output of Empresa Minera del Centro del Perú (Centromín Perú) as reported by the Ministerio de Energía y Minas.